Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	ET Docket No. 98-153
Regarding Ultra-Wideband Transmission	)	
Systems	)	

Ex Parte Comments of Delphi Corporation

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SUMMARY

Delphi Corporation ("Delphi") is the leading developer and manufacturer of vehicular radar systems in the United States. Using a variety of waveforms, Delphi's vehicular radar systems, for example, provide warning of potential obstacles or collision, automatically maintain a vehicle's speed and distance behind a lead vehicle, and prepare the vehicle to lessen the severity of unavoidable accidents. They not only have the potential to limit the impact of those accidents that do occur, but also to reduce the numbers of highway accidents, and resulting deaths and injuries, that occur in the first place. Delphi has had a vehicular radar device that uses low power, "ultra-wideband" ("UWB") techniques in production since June 2000.

Delphi provides its *Ex Parte* Comments in response to the Comments submitted by the National Telecommunications and Information Administration ("NTIA") in this proceeding on January 15, 2004. First, the NTIA Comments only reference the use of pulsed UWB operations for vehicular radar systems. Delphi, however, takes this opportunity to remind the NTIA and the Commission that phase modulation, which Delphi employs in its vehicular radar systems, is an acceptable technique to creating UWB waveforms. Second, NTIA stated its opposition to the proposal to eliminate the minimum bandwidth requirement currently in the Commission's UWB rules. Delphi supports elimination of this requirement. Utilizing smaller bandwidths for vehicular radar systems have the potential to provide important technical benefits as well as reducing the potential for causing harmful interference.

Finally, NTIA discusses the possibility that there may be a need to transition vehicular radar systems from the 22-29 GHz band the 77-81 GHz band. Delphi has been investigating the utility of the 77-81 GHz band for these devices, but has concluded that this band does not provide a suitable environment for the types of vehicular radar systems deployed in the 22-29

GHz band. Indeed, any relocation to the higher band would, according to Delphi's analysis, effectively render these systems cost-prohibitive. Delphi therefore would oppose any conclusion that the 77-81 GHz band would be suitable for relocation.

TABLE OF CONTENTS

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	)	
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To: The Commission

Delphi Corporation ("Delphi"), by its attorneys, respectfully submits these *Ex Parte* Comments in the above-captioned proceeding in response to the Comments of the National Telecommunications and Information Administration ("NTIA") submitted herein on January 15, 2004 ("NTIA Comments").[1] Delphi is a leader and innovator in the design and manufacture of vehicular radar systems and has actively and consistently participated in this proceeding. Delphi supports both the Federal Communications Commission ("Commission") and the NTIA in their efforts to continue evaluating the rules for ultra-wideband ("UWB") transmission systems.

Delphi has submitted Comments[2] on the *Further Notice of Proposed Rulemaking* ("*FNPRM*")[3] and will not restate here those Comments, nor will it address every issue discussed in the NTIA Comments. Delphi's *Ex Parte* Comments are limited to responding to the following

[1] *Comments of the National Telecommunications and Information Administration*, ET Docket No. 98-153 (submitted January 15, 2004).

[2] *Comments of Delphi Automotive Systems Corporation*, ET Docket No. 98-153 (submitted July 13, 2003).

[3] *In the Matter of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems,* Memorandum Opinion and Order and Further Notice of Proposed Rulemaking, ET Docket No. 98-153, 18 FCC Rcd 3857 (2003).

issues raised in the NTIA Comments: (1) the use of phase modulation to create UWB waveforms; (2) the proposed elimination of the minimum bandwidth requirement for UWB operations; and (3) the possible transition of vehicular short range radar ("SRR") operations from the 22-29 GHz band to the 77-81 GHz band.

I. BACKGROUND

According to the National Highway Traffic Safety Administration ("NHTSA"), there were over 6.3 million police-reported motor vehicle accidents in the United States, accounting for more than 3 million injuries and 42,000 deaths.[4] NHTSA estimates that, in 2000, the economic impact of motor vehicle accidents, reported and unreported, reached approximately $230.6 billion.[5]

Vehicular radar systems, such as those developed by Delphi, have the potential to reduce these numbers by reducing the likelihood of an accident occurring in the first place or, if an accident cannot be avoided, by mitigating its potential severity. Presently, there are three types of vehicular safety systems based on radar technology: (1) notification to the driver of potential obstacles or collision; (2) automatic response of the vehicle, such as applying the brakes; and (3) impact protection to lessen the severity of an unavoidable accident on the driver and passengers. Delphi's Back-up Aid (operating at 17 GHz and 24 GHz) can detect and alert a driver to an object behind a vehicle at five meters distance. Delphi has also developed radar-enabled Adaptive Cruise Control (at 76 GHz), which automatically maintains a vehicle's speed and distance between it and a lead vehicle. Future radar systems will detect and warn of objects at

[4] National Highway Traffic Safety Administration, Traffic Safety Facts 2001, 2 (December 2002).

[5] *Id.*

any point around a vehicle as well as initiate impact protection measures, such as tightening of seat belts, if an accident is unavoidable.

Delphi's vehicular radar systems employ a variety of waveforms, including frequency modulation continuous wave, pulse Doppler, frequency shift key, and spread spectrum waveforms using phase shift key modulation. Delphi has had vehicular radar systems based on low power, "ultra-wideband" ("UWB") techniques in production since June 2000. This product, the Delphi Back-up Aid ("BUA") radar sensor, was authorized under Part 15, subpart C of the Commission's Rules.[6] Delphi is also developing the second generation BUA products under the new UWB (Part 15, subpart F) vehicular radar allocation.

II. COMMENTS

A. Use of Phase Modulation

NTIA refers in its Comments to the use of limitations upon duty cycles as a means to further the proposal to define peak power in a 1 MHz bandwidth.[7] NTIA, more generally, references the use of pulsed UWB operations in its Comments. Delphi reminds the Commission and NTIA that phase modulation is also an acceptable technique to create UWB waveforms, as discussed in Delphi's Engineering Study[8] and as acknowledged in the Commission's *First Report and Order* in this proceeding.[9] Unlike amplitude pulsed emissions, phase modulated

[6] In June 2000, the Commission granted authority to Delphi to market and deploy its "UWB-like" vehicular radar systems under Part 15 as unlicensed devices pursuant to Rules 15.209 and 15.231, 47 C.F.R. §§ 15.209 and 15.231. Grant of Equipment Authorization, FCC Identifier L2C0004TR (June 1, 2000).

[7] NTIA Comments at 6-13.

[8] Submitted as an attachment to *Ex Parte Comments of Delphi Automotive Systems Corporation*, ET Docket No. 98-153 (submitted July 13, 2001) ("Engineering Study").

[9] *In the Matter of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, First Report and Order, ET Docket No. 98-153, 17 FCC Rcd 7435 (2002)

emissions – such as those developed by Delphi – do not employ duty cycles and, as such, may not be limited in this respect. Delphi urges that care be taken in formulating the rules so as not to prohibit the phase modulated waveform that employs a 100 percent duty cycle.

B. Restrictions on Pulse Repetition Frequency

Delphi agrees with the NTIA's recommendation that no restrictions on pulse repetition frequency (PRF) or device application are necessary if the Commission adopts the emission limits for hand-held UWB devices for expanded outdoor use.[10] The NTIA recommendation specifically covers both "impulse modulation" (pulse modulated radar) and "high speed chipping rates" (phase modulated radar) as currently permitted under the Commission's rules.

C. Non-UWB Peak Power

Delphi agrees with both the NTIA[11] and the Commission that rewording of paragraph 15.35(b) should be adopted. Non-UWB devices should not be forced to operate at power levels lower than UWB devices when located in frequency bands allocated for use.

D. Elimination of Minimum Bandwidth from UWB definition

NTIA opposes the elimination of the minimum bandwidth requirement, arguing that it may disrupt current UWB product development efforts and delay UWB availability.[12] Delphi does not share NTIA's concern that this change in the UWB rules would disrupt current UWB product development. Indeed, Delphi anticipates that UWB products will be introduced in compliance with existing rules as planned and that the change in rules would spur the

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("*First Report and Order*").

[10] NTIA Comments at 3-5.

[11] *Id.* at 5-6.

[12] *Id.* at 23-25.

development of additional UWB devices or next generation products that may benefit from the efficiencies available from narrower-banded UWB devices. Delphi thus agrees with the Commission's proposal to eliminate the minimum bandwidth requirement from the UWB definition.

Delphi recognizes that for UWB in general operating at any frequency, there may be a concern over narrowband devices operating in the restricted zones unnecessarily. The following discussion applies only to the 22-29 GHz automotive UWB radar band. In its previous comments,[13] Delphi has shown that a low bandwidth device that meets the power spectral density, average power, and peak power rules as currently specified for automotive UWB radars will have less potential for interference than a wide bandwidth device. The automotive UWB radar rules require that any device operating in the 22-29 GHz band shall have a center frequency greater than 24.065 GHz. This prevents any device with bandwidth less than 130 MHz from intentionally radiating into the 23.6 – 24.0 GHz RA and EESS restricted band.

Delphi also showed how a narrower band signal would be used in an automotive application.[14] The back-up aid ("BUA") device, for example, is a radar located on the rear of a vehicle, and is activated when the vehicle driver puts the vehicle's transmission into "reverse". The BUA radar scans an area behind the vehicle that extends slightly over 5 meters to the rear by positioning a range bin at a particular distance for a time, then re-positioning the bin in a contiguous position for a time, and repeating the bin repositioning process until the entire 5 meter depth of coverage is realized, see Figure 1.

[13] Engineering Study.

[14] *Id*.

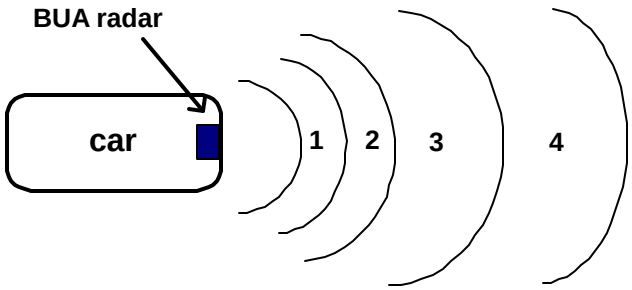

Figure 1. The BUA radar sequentially positions its single range bin to cover the entire desired area to the automobile rear. Using a variable width range bin vs. bin position preserves both response time and range data accuracy where needed.

The above figure illustrates the benefit of allowing smaller bandwidth, when we realize that the range bin depth is inversely proportional to bandwidth. The figure shows the usage of wider range bins at longer distances from the car (positions 3 & 4), and thinner range bins close to the car (positions 1 &2). This is driven by the need to have more accurate ranging data when objects are closer to the car. By using wider range bins (lower radiated bandwidth) in positions 3 and 4, the number of unique range bins, hence system cost, may be minimized. The radiated bandwidth needed to achieve the wider range bins in positions 3 and 4 is less than the minimum bandwidth requirement of 500 MHz for an automotive UWB radar.

The system response time (time delay between first presence of an object in the zone of coverage and the radar detecting the object) is of critical importance in automotive radar products. Using the scheme in Figure 1 can reduce the number of range bins that need be processed without sacrificing response times or the range data accuracy required at only the close ranges. This is an example of improved cost effectiveness that cannot be achieved without reduction of the minimum bandwidth requirement for an automotive UWB radar, as the wider range bins radiate a bandwidth less than UWB minimum bandwidth requirement while the “thin”

range bins require greater than 2 GHz bandwidth, hence the device can only be licensed as an automotive UWB radar. Furthermore, multi-mode automotive radars now in development utilize variable range bin size depending on the operating mode. Multi-mode radars perform multiple functions at lower cost than several individual radars for each application. For some applications, the optimum size of the "wide" range bins is one meter. This requires a main-lobe null to null bandwidth of 300 MHz. This is a condition not allowed by existing automotive UWB radar rules pertaining to the 22-29 GHz band.

Radar devices with lower bandwidths have less interference potential to existing radio services. A lower bandwidth signal relative to a higher bandwidth signal (where both signals have the same maximum power spectral density) radiates less total power and will cause less interference to receivers than the wider band emission. A direct comparison between two wideband emissions is given in Figure 2.

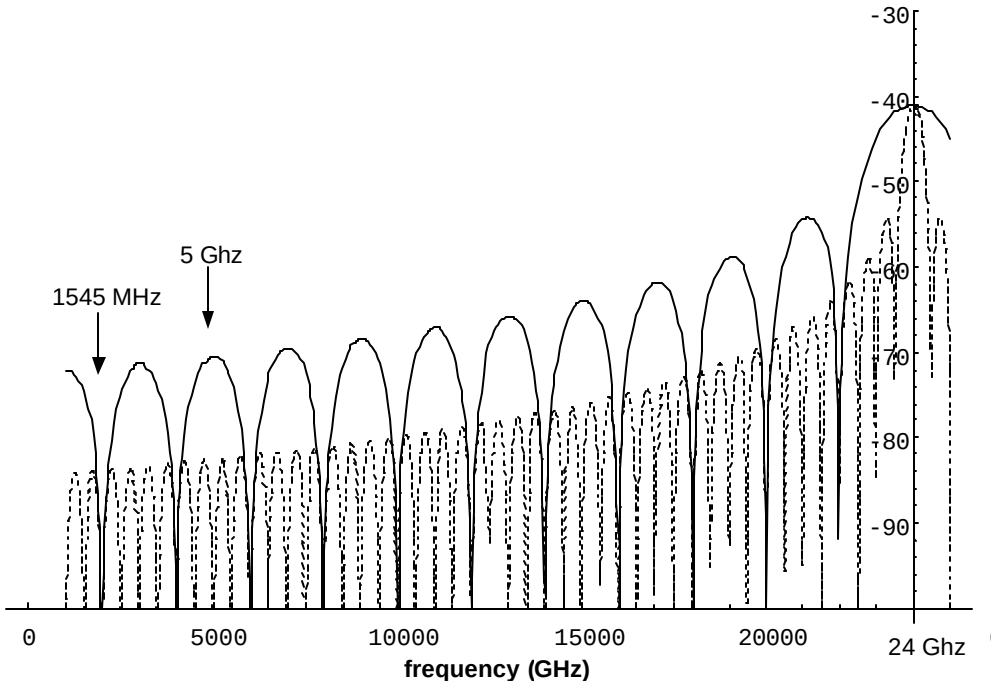

Figure 2. Power spectral density plot from 1 GHz to 25 GHz (where the main lobes are centered at 24 GHz) of two wideband signals. The dashed line signal has a mainlobe null to null bandwidth of 1 GHz. The solid line signal has a mainlobe bandwidth of 4 GHz (null to null).

E. Comments on 77-81 GHz:

Finally, NTIA references the possibility that technical and economic factors may result in the transition of vehicular radar operations from the 22-29 GHz band to the 77-81 GHz band.[15] NTIA notes that given the sensitivity of Earth-Exploration Satellite Service (EESS) operations between 23.6 and 24 GHz, the Commission's Rules require short range vehicular radar systems to employ increasing levels of attenuation over the next ten years. NTIA also cites discussions in Europe regarding possible interference in the 24 GHz band between UWB type vehicular radar systems and fixed systems. NTIA further cites to Delphi's Comments in this Docket that design, production and deployment of radars in the 76-77 GHz band has commenced.[16]

Delphi is the world's leader in the development and deployment of automotive radars and is, as has been suggested in this and other Dockets, investigating the utility of the 77-81 GHz band for certain automotive radar operations. Delphi, indeed, has developed a long range radar for deployment in the 76-77 GHz band. However, while Delphi believes that the W Band may provide a usable environment for medium range radar applications, such as a pre-crash sensing radar, it does not believe that the W Band will provide a suitable environment for short range radar ("SRR") applications of the type deployed in the 22-29 GHz band. Indeed, any dislocation of the SRR operations to the W band, in Delphi's view, effectively will render SRR deployment cost-prohibitive. Delphi is committed to exploring other alternatives to better accommodate

[15] NTIA Comments at 19-22.

[16] *Id.* at 19.

SRR operations in the longer term and intends to engage both the Commission and NTIA on this issue. Delphi urges the Commission here to refrain from any conclusion that the W Band will provide a suitable home for the relocation of 24 GHz band SRR products.

Delphi does not believe that the cost of 77-81 GHz components will drop very much in the near future. Delphi believes that the cost of 22-29 GHz components will always be lower than the cost of 77-81 GHz components, and that they will be significantly lower for the foreseeable future. If stand alone short range sensors are to be implemented in a large number of "affordable" medium priced vehicles, those sensors will be operating in the 22-29 GHz frequency range. Delphi believes that there are design approaches available, other than moving SRR to 77-81 GHz, which can avoid intentional (main lobe) radiation into the 23.6 to 24.0 GHz RA and EESS restricted bands (See Figure 3). Delphi also believes that 7 GHz of bandwidth is not required for automotive applications, and that almost any application can be adequately handled with a 5 GHz bandwidth.

An important issue related to the choice of center frequency of UWB operation is un-modulated carrier leakage. Un-modulated carrier leakage is a technical concern for all automotive suppliers of UWB devices. It is perceived that un-modulated carrier leakage (LO leakage and LO harmonic leakage) will more likely be allowed if it occurs in the 24 GHz ISM band (always above 24.065 GHz) where higher power (+13 dBm) devices operate. Unfortunately, the wording in the Commission's *First Report and Order* leaves un-modulated carrier leakage (LO leakage and LO harmonic leakage) performance parameters open for interpretation. Footnote 405 discusses residual carrier and LO leakage and states that the issue will be resolved at the time of submittal for certification.[17] As a consequence of footnote 405,

[17] *First Report and Order*, 17 FCC Rcd at 7525 n.405.

UWB designs will tend to operate with a center frequency in the ISM band to ease the hurdle of obtaining approval to operate with un-modulated carrier leakage. Operating at center frequencies near 26.5 GHz, with corresponding restricted band intentional emissions eliminated, is dissuaded by the lack of un-modulated carrier leakage limits in the UWB rules. Considering the millions of dollars that are invested during product development, not knowing if a product will be certified greatly diminishes the likelihood that such products will be developed.

If the Commission were to allow, for example, –20dBm EIRP residual carrier leakage in the band 24-29 GHz, it would become very attractive for the automotive radar industry to re-center their equipment to have a center frequency greater than 24.8 GHz. The (sinx)/x characteristic of the power spectrum of both pulsed and phase modulated waveforms versus frequency would greatly diminish the energy radiated into the restricted band if the UWB device operates at 24.8 GHz or higher. Continued deployment of vehicular radar systems in the 24-29 GHz band will result in lower cost to the consumer and increased availability to the general public.

Delphi realizes that the chance for harmonized bands with Europe at 24 GHz may not be possible at this time except on a temporary basis; however, Delphi also believes that W-band will not be a cost effective solution to mitigating intentional emissions within the EESS band. Delphi strongly believes, as illustrated in Figure 3, below that with minor rules changes in the 24-29 GHz band a cost effective solution to the 23.6-24 GHz restricted band issue can be accomplished.

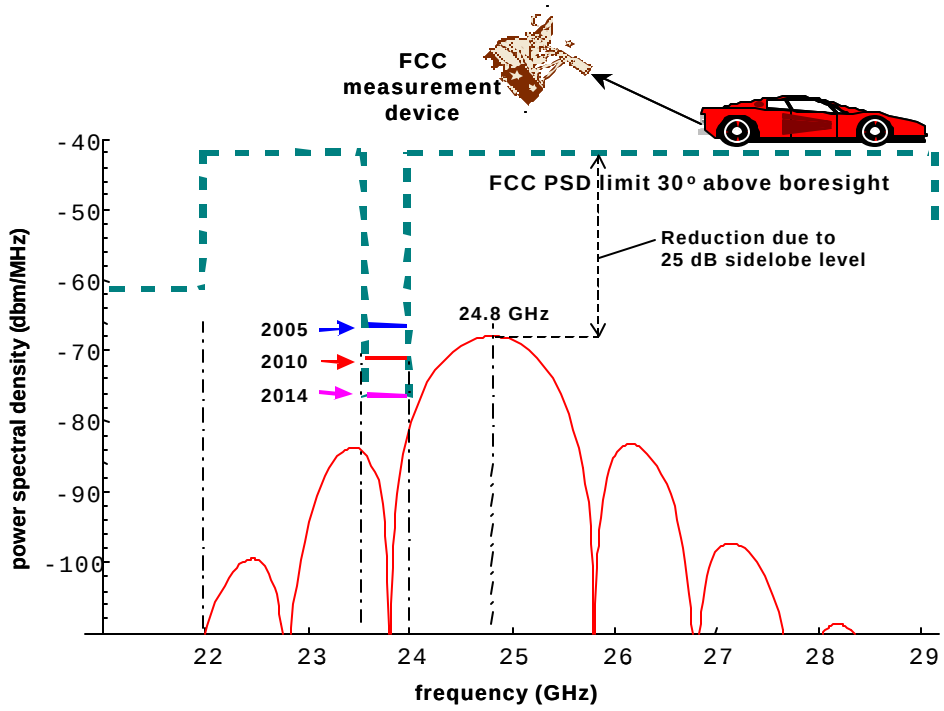

Figure 3. Moving to 24.8 GHz center frequency establishes significant margin relative to the UWB elevation requirements. Moving to approximately 25 GHz puts the entire main lobe above the 24 GHz restricted band. Power spectrum shown as radiated through a 25 db sidelobe transmit antenna.

III. CONCLUSION

As acknowledged by the Commission in its *First Report and Order*, Delphi reminds the Commission and NTIA that that phase modulation, such as employed by Delphi's UWB vehicular radar systems, is an acceptable technique to create UWB waveforms. Delphi also supports the Commission's recommendation that the minimum bandwidth limitation be eliminated. Finally, Delphi asks that the Commission and the NTIA refrain from concluding that the 77-81 GHz band is suitable for the relocation of 24 GHz band UWB SRR products.

Respectfully submitted,

Delphi Corporation

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